Constraints on Proton Driver from Downstream Systems in a Neutrino Factory

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BNL ISS Proton Driver Meeting

4 January 2006

Bunch Structure (in acceleration)

- Overall rep rate, period T

- Multiple pulses within period T, generally closely spaced

- Bunches within these pulses, at RF frequency

Phase Rotation

- Two types of systems proposed
  - Induction linac (**EXPENSIVE**)
  - Neuffer RF phase rotation

- System must reset itself between pulses
  - Neuffer RF scheme needs fill time: 200 μs
  - Induction linac scheme: rate of voltage change limited (probably 100s of ns to reset)

- Operating cost proportional to rep rate times number of pulses
  - Stored energy lost
  - Can keep stored energy somehow?

- Longitudinal phase space area
  - Shorter proton bunch, smaller longitudinal phase space
  - Finite time spread from decays: about 1 ns; no point in doing better

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Acceleration

- Some circumferences small: 300 m
  - If both signs: essentially only one pulse

- Portion of operating cost proportional to rep rate
  - Stored energy in cavities lost
  - Cryo load; increases with more pulses also

- Higher rep rate, decrease beam loading (energy spread in train)

Storage Ring Assumptions

- Injection and extraction are done actively
- Stacking is not possible
  - Transverse stacking
    - Larger transverse size requires larger beta function in straight (divergence)
    - Larger aperture required both from larger phase space size and larger beta
    - How to do it…
  - Bucket too full for longitudinal stacking
- Must keep beam in for a few decay lifetimes
  - 3 lifetimes is 5% loss, 1% loss requires 4.6 lifetimes

Storage Ring
Resulting Constraints

- Rep rate
  - For 50 GeV, 200 Hz starts eating into muons (1%); 300 Hz becomes a problem (5%)
  - At 20 GeV, the numbers are 500 Hz and 800 Hz

- Bunch trains
  - With 100 m bunch trains, you may be able to squeeze a second or third bunch train in (kicker rise/fall times)
    - More difficult with both charges in same ring
    - Could increase effective rep rate as well by doing this
  - Don't stack

Detector

- Well below surface: agnostic

- Near surface: use gating to reduce backgrounds
  - Pulse structure (inversely proportinal to rep rate; biggest effect)
  - Gap in storage ring (reduced with more pulses in ring)
  - Fine structure at RF frequency

- Prefer lower rep rate, single pulse in ring